NASA TECH BRIEF

Balloon Batteries, Charged and Heated by Solar Energy

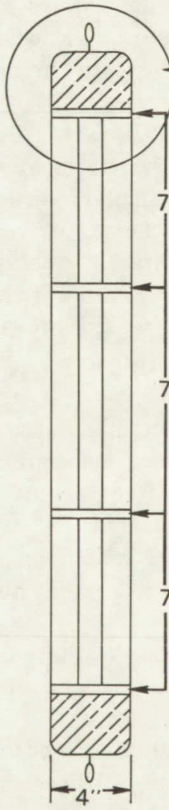

Figure 1. Solar-Thermal Module

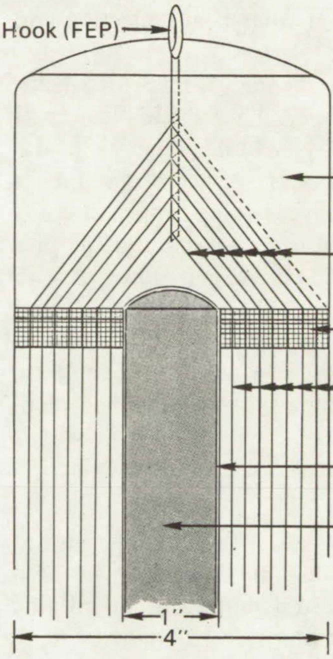

Figure 2. Solar-Thermal Module Suspension Cap

The problem:

To maintain nearly constant temperature of a device subject to solar heating at night cycles at an altitude of 30,000 feet. The thermal system must have low density to avoid damage to aircraft in case of impact.

Long range weather forecasting of the World Wide Weather Watch will use several thousand balloons circling the earth at altitudes of 30,000 feet or more. The balloons will have an electronic communication system powered with solar cells and a storage battery. They should serve for at least six months, broadcasting weather information to a satellite.

Electric power, generated by solar cells only during daylight, must be stored for operation during dark

(continued overleaf)

periods. Storage batteries must be available to be charged and discharged every day for a total of nearly 200 cycles. Dependable nickel-cadmium ("Ni-Cad") batteries are known to deliver about 15 watts per pound weight, but the power slowly decreases as the battery gets colder. At the altitude of the balloons, ambient temperatures vary from –30°C in the sun to –60°C at night. The electric power output of the Ni-Cad batteries drops to zero at such low temperatures. Special batteries are available, but they supply only a few watt-hours per pound and are not as reliable. The problem is to maintain the Ni-Cad battery at a temperature within the range –20 to –30°C (–4 to –22°F).

The solution:

It is logical to turn to the sun for heat, partly because it powers the solar cells that operate the device. The collection and storage of solar heat have been experimentally tested for such applications at heating houses and distilling sea water. The solar-thermal module adapts this experience to enclose the balloon battery within a solar heat collecting and storing "house" of its own.

This is accomplished by means of a shielded heat-of-fusion material envelope. The shield transmits maximum solar radiation by day and provides insulation by night. It consists of a spiral-wound fluoroplastic (FEP) film structure having approximately eight layers. The heat-of fusion material consists of a specially developed Solar Heat Storage material with a high heat capacity (above 200 Btu per pound) and with a melting point of –23°C.

The final battery package consisting of battery, shield, and heat storage material, has an aspect density less than 5 g per square cm (approximately 1 oz per square in.).

How it's done:

The basic requirements for the system are as follows: (1) the solar thermal module must be light weight and frangible to avoid danger to high-flying jet aircraft; (2) the insulation must be transparent to solar radiation to absorb the most heat during the day, and nearly opaque to infrared radiation to retain the most heat at night; (3) the insulation material must be resistant to radiation damage and discoloration to retain its effectiveness during the six month lifetime of the balloon; and (4) the temperature of the battery must remain above –30°C when held in a nighttime ambient temperature of –60°C for twelve hours to permit 24-hour operation.

The size and shape of the present solar-thermal module is shown in Figure 1. It is approximately the same diameter but only half the length of the final balloon device. Figure 2 presents an enlarged, cutaway view showing the location of the various components.

The battery consists of cylindrical plates approximately one inch in diameter, sealed into a plastic film container. The space inside the battery cylinder is filled with solar heat storage material, thickened into a gel to prevent leakage, and mixed with crystal nuclei to promote prompt and uniform crystallization. Around the battery cylinder are wrapped eight layers of a fluoroplastic (FEP) film, spaced approximately 0.2 inch apart by means of flexible urethane form spacers, which are inserted every 7 inches along the length of the tube. The ends are capped with rigid urethane foam thermal insulators. The whole solar-thermal module is suspended beneath the balloon by means of a plastic hook.

The FEP structure transmits nearly 70% of the incident solar energy to the heat storage material. The heat storage material, together with the air spaces between the plastic sheets, is capable of maintaining the battery temperature at or above –30°C for a period of 14 hours when initially charged to 25°C, the temperature which would prevail at the end of a clear day.

Notes:

1. Battery heat loss may be further reduced by using selective black coatings, which were not available for use during the testing of the prototype solar-thermal module.
2. Different solar heat storage materials are available to maintain temperatures at a number of different levels.
3. This system may be of interest to those concerned with stabilization of extreme temperature environments.
4. Requests for further information may be directed to:

   Technology Utilization Officer
   Goddard Space Flight Center
   Greenbelt, Maryland 20771
   Reference: TSP69-10585

Patent status:

No patent action is contemplated by NASA.

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